

Eastern Interconnect Baseline Data Analysis

PNNL portion of the PJM/EPG/PNNL project

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Goals

- ▶ Estimate typical and atypical limits of phase angle difference between pairs of sites
 - Analyze datasets to identify
 1. typical angle difference patterns over different periods (e.g. seasonal patterns, on-peak/off-peak patterns);
 2. atypical patterns;
 3. precursors to significant events; and
 4. phase angle clusters.
 - Correlate atypical patterns and events to grid conditions (e.g. transmission system congestion, var support, outages etc) using associated system information.
 - Suggest list of angle difference pairs to be monitored in real-time and their alarming limits.



Approach

▶ Two approaches

■ Statistical Quality Control investigation

● Uses ANOVA with

- ◆ Seasonal factors (4,6,13 seasons)
- ◆ Day of Week (7 days or weekdays/weekends)
- ◆ Time of Day (eight 3-hour periods)
- ◆ Holiday
- ◆ Interactions (maybe)

● Calculate recommended limits using SQC practices

■ Adapt Morning Report Analysis

- Multivariate statistical analysis of datasets to identify
- Refine work completed to date
- Capture typical patterns (phase angle clusters)
- Identify atypical events

▶ Investigate precursors to significant events

In work

Preliminary

To be done

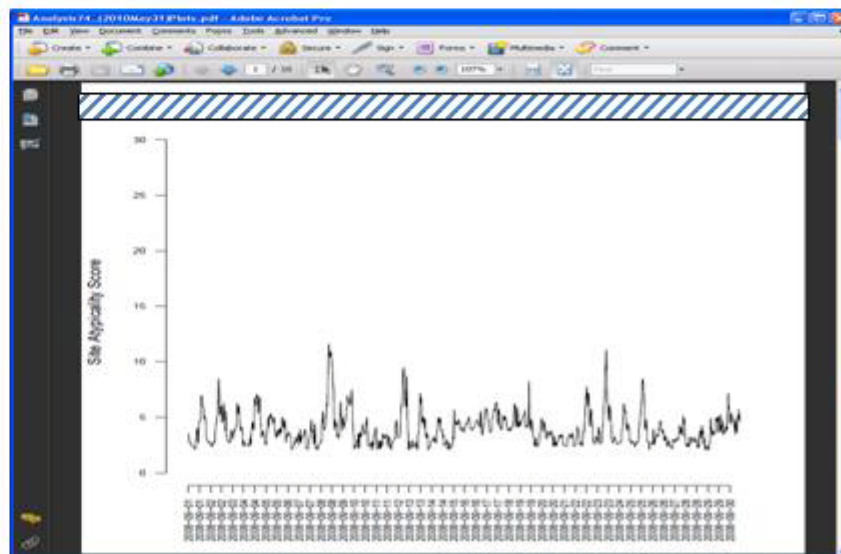
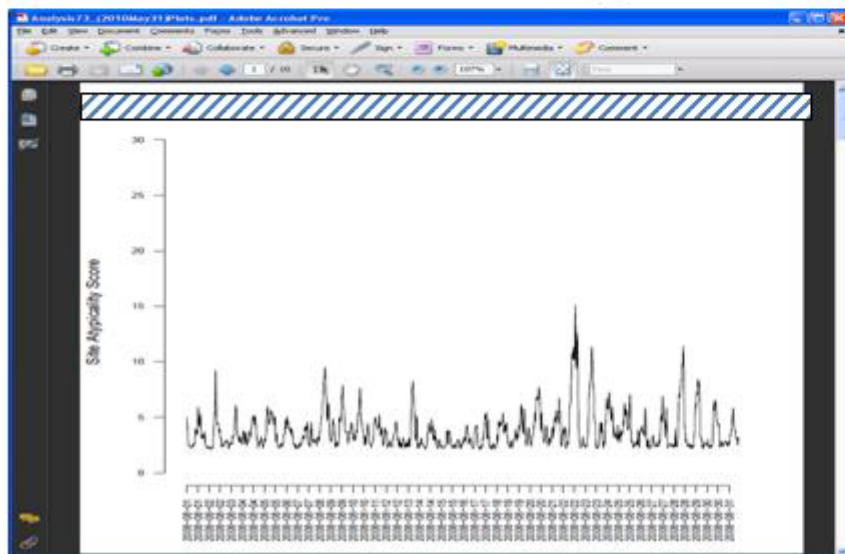
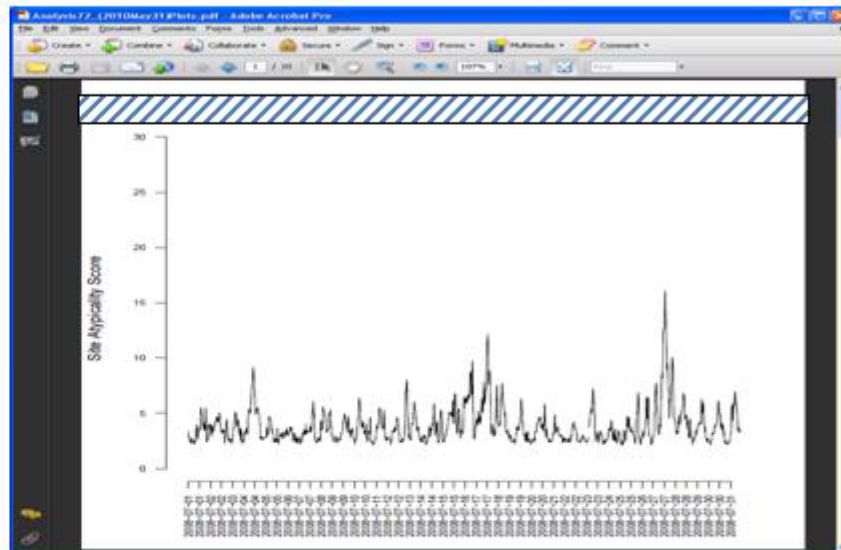
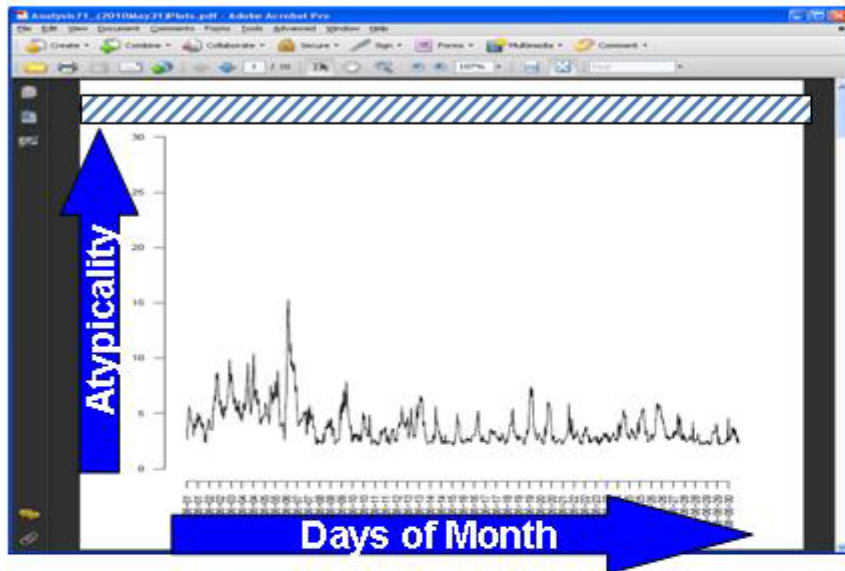


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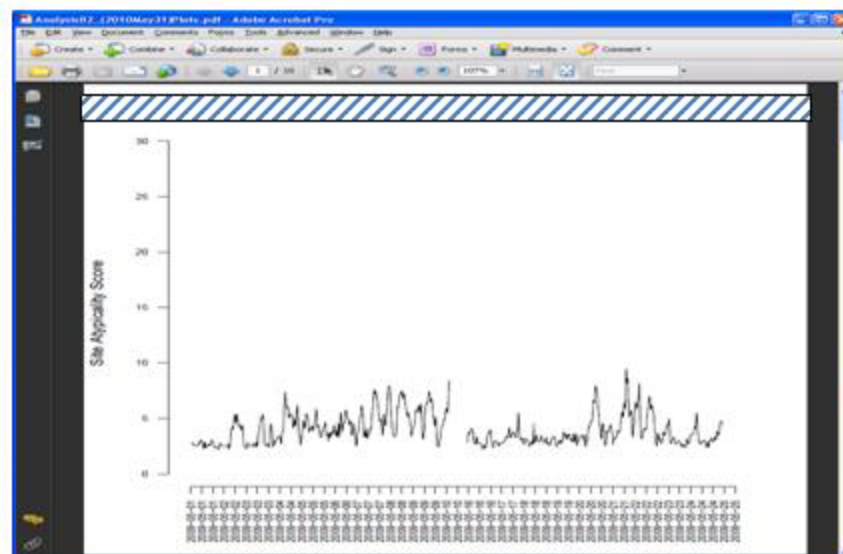
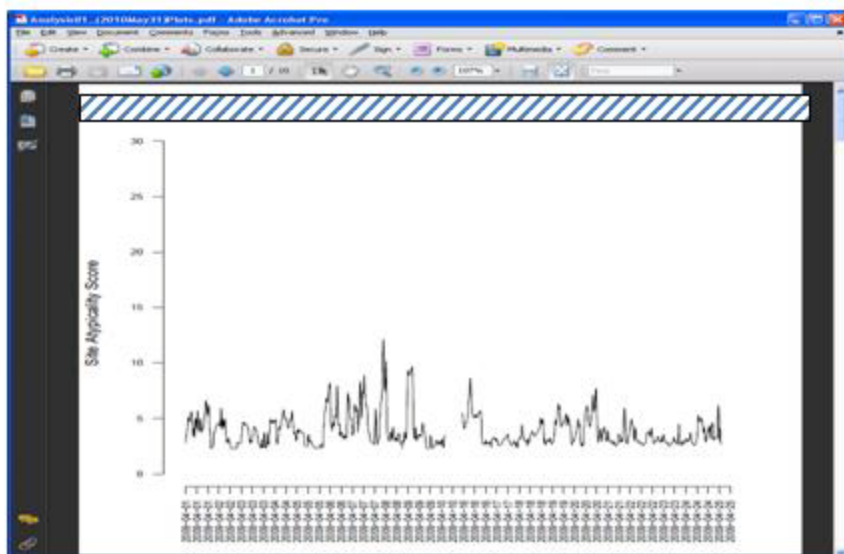
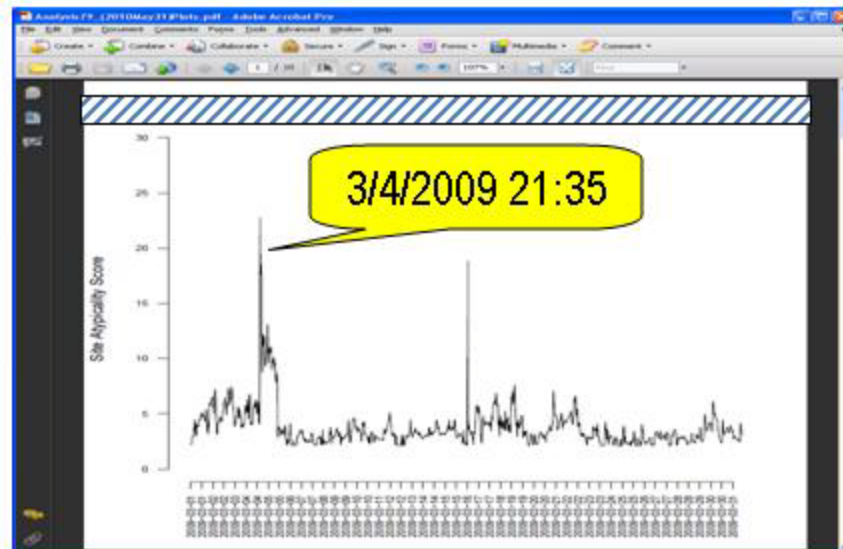
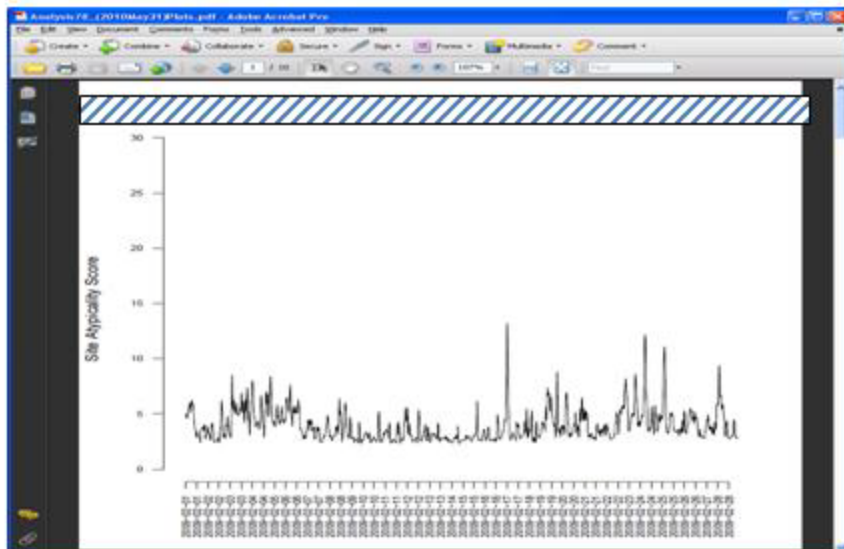
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Atypicality Plots

June 2008 to September 2008



Atypicality Plots February 2009 to May 2009



Rationale circa November 25, 2008 18:20 When Atypical events are detected. What made them stand out as atypical.

Microsoft Excel - Analysis80_(2010May31)Report

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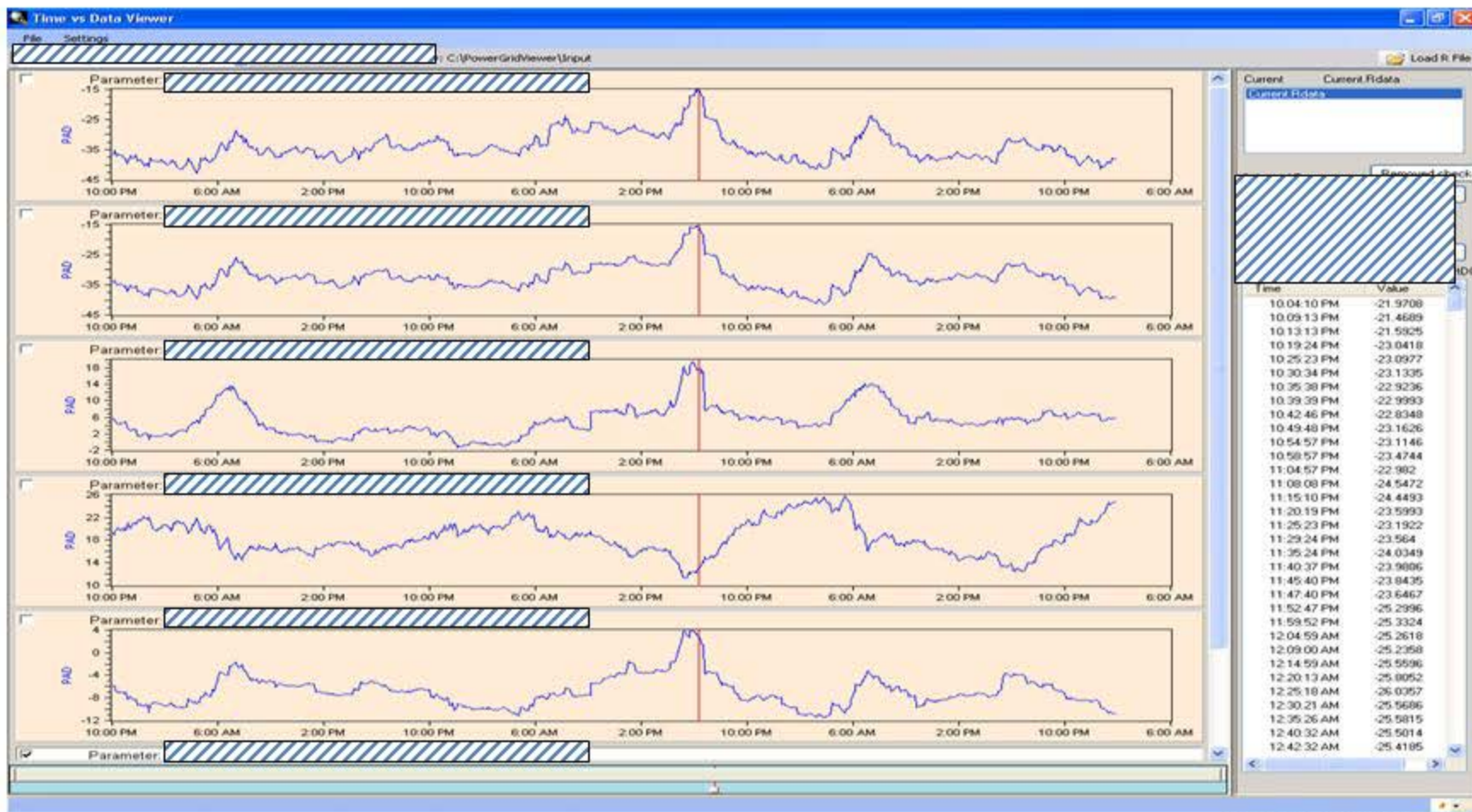
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	A	B	F	I	J	P
	Gas	Atyp. Percentile	Time	Analysis	Variables	Value/Rationale
1	0.45					
2	20.7	0.999	11/25/2008 18:20	80	all	Dwart mean (mean=18.83) was very high. Owart mean (mean=4) was very high. Owart mean (mean=-7.19) was very high. Dwart mean (mean=-16.03) was very high. wirtD mean (mean=-10.51) was very high. Dwart mean (mean=-21.23) was very low. wirtI mean (mean=-17.44) was very high. Dwart mean (mean=-2.394) was very high. Swart mean (mean=-2.689) was high.
3	19.6	0.999	11/25/2008 18:15	80	all	Dwart mean (mean=18.78) was very high. Owart mean (mean=4.043) was very high. Owart mean (mean=-7.283) was very high. wirtD mean (mean=-10.41) was very high. Dwart mean (mean=-16.34) was very high. Dwart mean (mean=-21.46) was very low. wirtI mean (mean=-18.13) was very high. Dwart mean (mean=-2.672) was high. Swart mean (mean=-2.784) was high.
4	19.1	0.999	11/25/2008 18:26	80	all	Dwart mean (mean=18.83) was very high. Owart mean (mean=3.915) was very high. Owart mean (mean=-7.159) was very high. Dwart mean (mean=-15.77) was very high. wirtD mean (mean=-10.68) was very high. Dwart mean (mean=-20.95) was very low. wirtI mean (mean=-16.78) was very high. Dwart mean (mean=-2.123) was very high. Swart mean (mean=-2.596) was very high.
5	18.7	0.999	11/25/2008 18:10	80	all	Owart mean (mean=4.035) was very high. Dwart mean (mean=18.68) was very high. Owart mean (mean=-7.453) was very high. wirtD mean (mean=-10.39) was very high. Dwart mean (mean=-21.64) was very low. wirtI mean (mean=-16.74) was very high. Dwart mean (mean=-18.88) was very high. Dwart mean (mean=-2.962) was high. Swart mean (mean=-2.885) was high.
						Dwart mean (mean=18.74) was very high. Owart mean (mean=3.76) was very high. Owart mean (mean=-7.215) was very high.

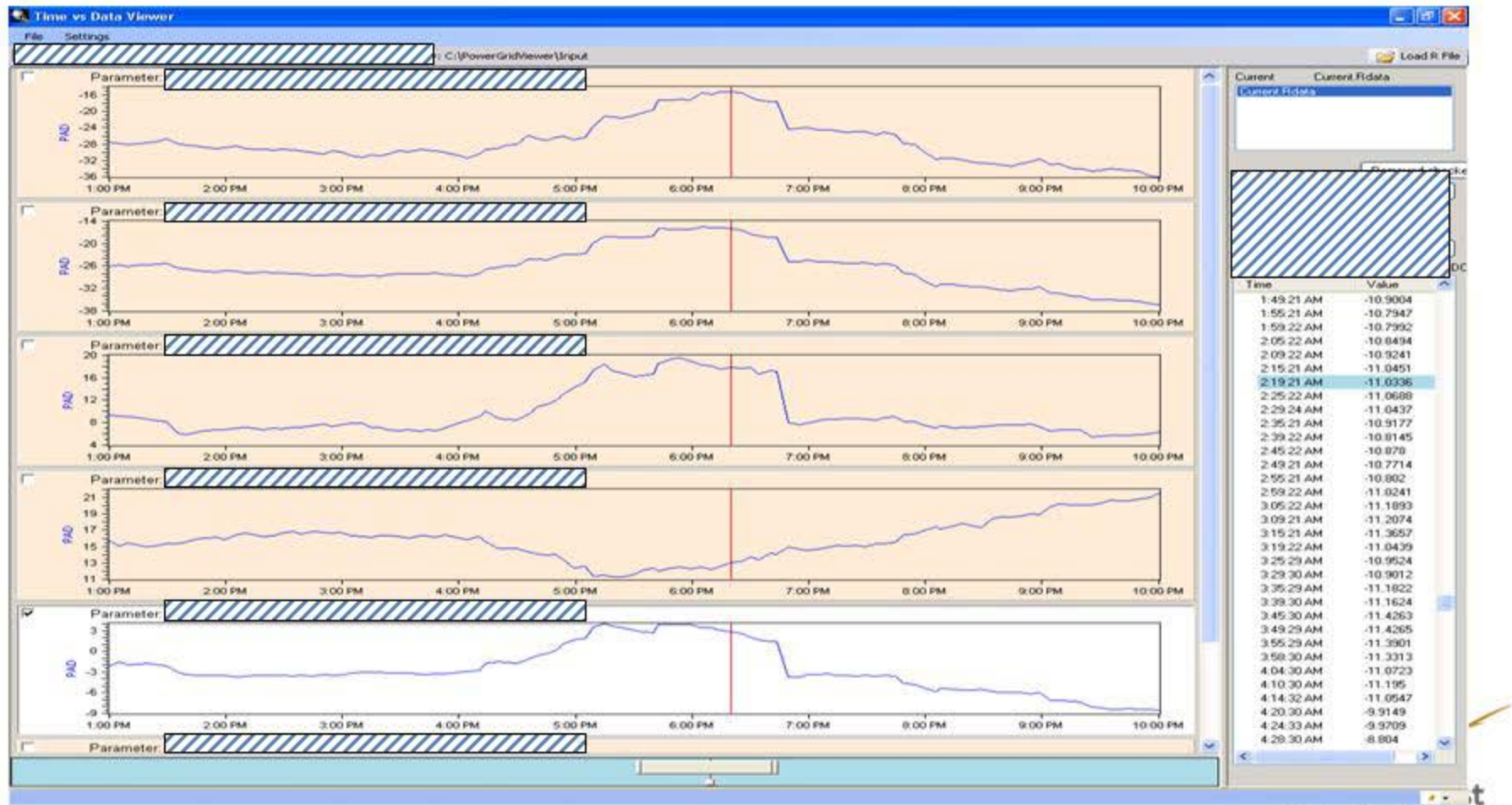
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Drill down plots

74 hours centered around 25-nov-2008 ~18:20:00



Drill down plots zoomed in 9 hours centered around 25-nov-2008 ~18:20:00



25-nov-2008 18:20:00

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Rationale circa March 4, 2009 21:35

When Atypical events are detected.

What made them stand out as atypical.

Microsoft Excel - Analysis79_(2010May31)Report

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Q1 SlopeRationale

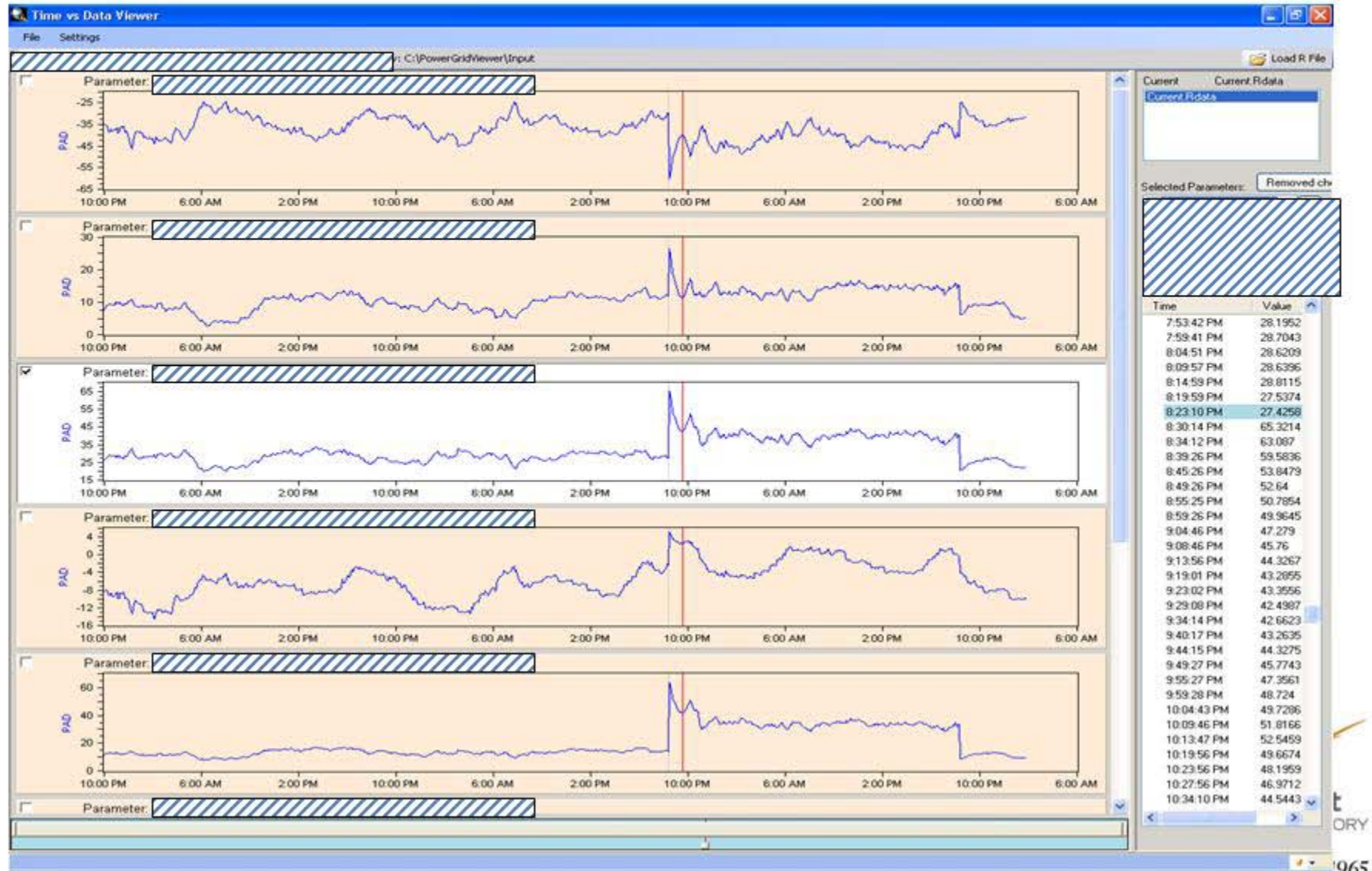
	A	B	F	I	J	P
	GAS	Atyp. Percentile	Time	Analysis	Variables	Values/Rationale
1						
2	22.8	0.999	3/4/2009 21:35	79	all	mean (mean=52.79) was very high. mean (mean=42.37) was very high. mean (mean=52.56) was very high. mean (mean=4.349) was very high. mean (mean=17.08) was very high. mean (mean=-48.44) was very low. mean (mean=4.118) was very high. mean (mean=-38.02) was low. mean (mean=-1.9) was low.
3	21.7	0.999	3/4/2009 21:30	79	all	mean (mean=53.01) was very high. mean (mean=42.2) was very high. mean (mean=53.28) was very high. mean (mean=3.822) was very high. mean (mean=17.95) was very high. mean (mean=-49.19) was very low. mean (mean=4.094) was very high. mean (mean=-38.38) was low. mean (mean=47.48) was high.
4	20.6	0.999	3/4/2009 21:25	79	all	mean (mean=51.05) was very high. mean (mean=40.05) was very high. mean (mean=52.4) was very high. mean (mean=2.352) was very high. mean (mean=18.23) was very high. mean (mean=-48.7) was very low. mean (mean=3.704) was very high. mean (mean=48.51) was very high. mean (mean=51.3) was high.
5	20.1	0.999	3/4/2009 21:20	79	all	mean (mean=49.01) was very high. mean (mean=37.84) was very high. mean (mean=51.45) was very high. mean (mean=18.44) was very high. mean (mean=0.8493) was very high. mean (mean=-48.16) was very low. mean (mean=49.43) was very high. mean (mean=52.47) was high. mean (mean=3.286) was high.
						mean (mean=41.75) was very high. mean (mean=51.74) was very high. mean (mean=51.24) was very high.

Ready

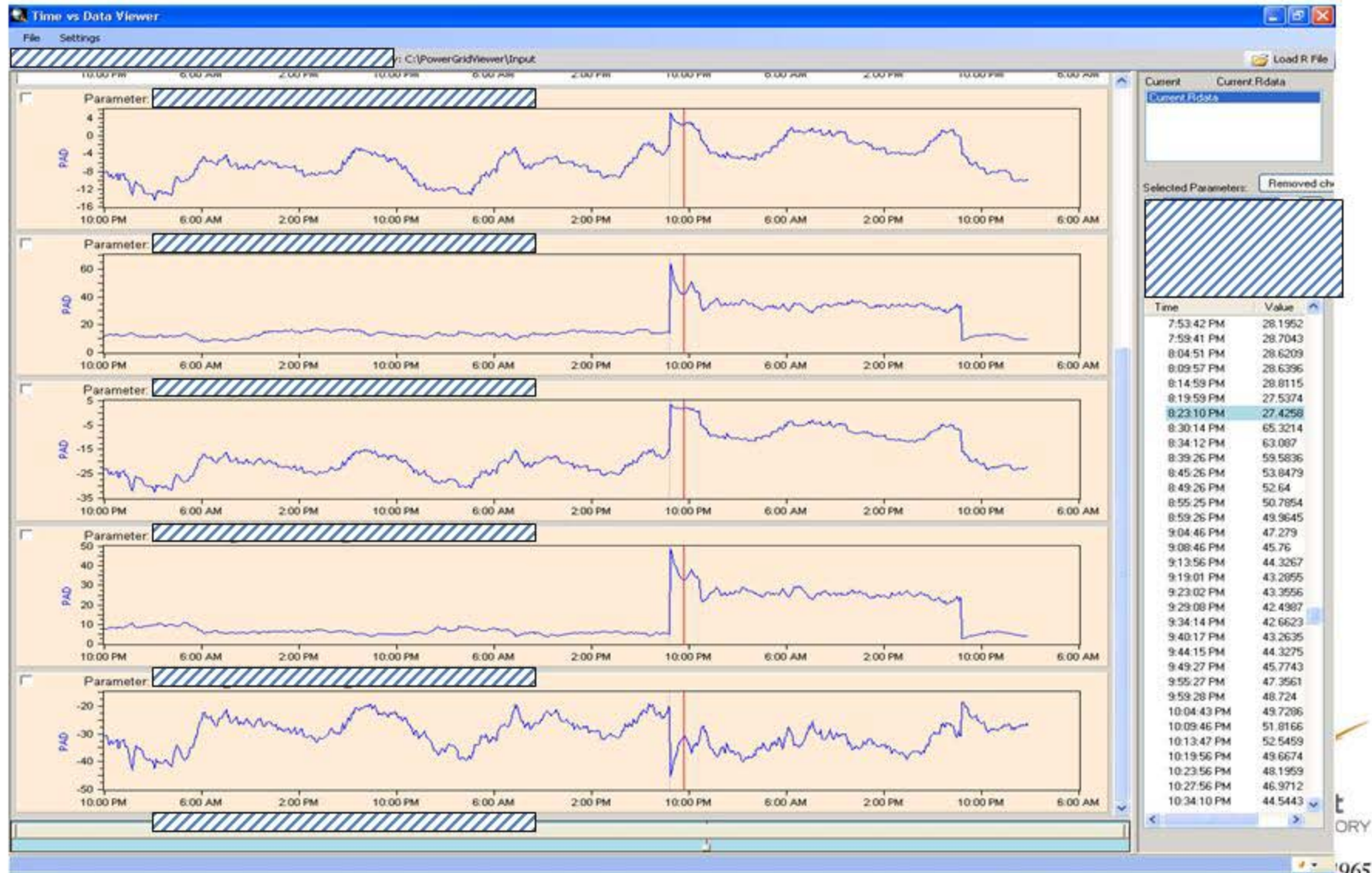
NUM

1/10/2010 10:00:00 AM

74 hours centered around 4-March-2009 ~21:35



74 hours centered around 4-March-2009 ~21:35



Zoom in 38 hours centered around 4-March-2009 ~21:35

~24 hour duration



Much is yet to be done

- ▶ SQC process investigation
 - Need to refine preliminary work
- ▶ Multivariate statistical analysis of datasets to identify
 - Need to refine preliminary work
 - Capture phase angle clusters
- ▶ Investigate precursors to significant events
- ▶ Correlate atypical patterns and events to grid conditions (e.g. transmission system congestion, var support, outages etc) using associated system information.
- ▶ Suggest list of angle difference pairs to be monitored in real-time and their alarming limits.

